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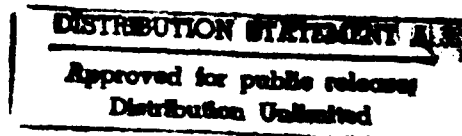


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**A RAND NOTE**

**Future Soviet Investment in Transportation,  
Energy, and Environmental Protection**

**Jeannette VanWinkle, Benjamin Zycher**



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**N-3173-USDP**

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**Prepared for the  
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## PREFACE

This document is part of a RAND project on "Gorbachev's Allocative Choices," an ongoing study in the International Economic Policy Program of RAND's National Defense Research Institute, a federally funded research and development center sponsored by the Office of the Secretary of Defense and the Joint Chiefs of Staff. The project, supported by the Under Secretary of Defense for Policy, assesses the prevailing conditions in various sectors of the Soviet economy and the competing claims of each sector on economic resources. A companion report, R-3891-USDP, formulates alternative choices that the Soviet leadership may make among these competing claims and analyzes the consequences of these choices. To highlight the conflicting allocative choices facing the Soviet leadership, the project is undertaking separate sub-studies of particular sectors, focusing on alternative resource demands that these sectors may generate.

The document outlines the current condition of the Soviet infrastructure including transportation, energy, and environmental protection.

## SUMMARY

→ This study outlines the current state of the transportation, energy, and environmental protection sectors in the Soviet economy. It also projects investment schedules for these sectors. Of the three areas, energy seems to be the least troubled. Both transportation and environmental protection have suffered from years of neglect and will continue to deteriorate unless priorities are substantially changed..

The transportation system depends heavily on rail. Unfortunately, the rail network has been deteriorating rapidly, because of low levels of maintenance and increased demands for freight transport. A crisis in rail transport occurred in the early 1980s but was remedied through increasing rail loads and tightening schedules. This solution has proved a temporary one, as the greater demands on the system have led to increasing wear on fixed capital assets. Although the Soviet leadership recognizes the need for greater expenditures on the rail network, proposed future investment seems inadequate to solve the problem. The rail lines will probably continue to create bottlenecks in the Soviet economy for the next several years.

Automobile transportation is a growing but still small part of the overall transportation network. It is hampered by both the quality of the roads and the poor quality of truck and automobile manufacturing. Although trucking will probably take over a greater share of the short freight hauls, it cannot act as a substitute for the rail system.

The energy sector has proved more efficient, and infinitely more profitable, than the other two. A new demand facing investment in energy will be nuclear safety retrofit. Costs for conventional fuels for thermal electricity generation have increased substantially and this, plus the disaster at Chernobyl, have put pressures for greater, but safer, uses of nuclear power.

Environmental protection is now receiving substantial attention from the leadership, largely because of international concern for environmental issues. The traditional Soviet practices of extensive

rather than intensive growth have led to dangerous levels of air and water pollution. In addition, irresponsible water reclamation has led to erosion and salinization of farm land and destruction of important water sources. ~~\_\_\_\_\_~~

Unfortunately, environmental protection has one of the lowest investment priorities, because it is a drain on short-term profits. The Soviets have an additional problem in that much of the advanced pollution control technology is available only through import. When allocations for purchase of pollution control equipment are made, industries have often diverted those assets into other expenditures. Despite strong statements by Ryzhkov and others, investment in environmental protection will likely be compromised by the demands in other sectors of the economy.

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## I. INTRODUCTION

The final productivity of an economy rests heavily on the structure supporting its industry. The transportation system and energy supply can either facilitate production and distribution or they can be the cause of work slowdowns and shortages. Soviet planners, who have made conscientious efforts to fine-tune and coordinate all sectors of the economy, are well aware of the critical importance of transportation and energy in achieving their goals for economic growth. Unfortunately these sectors, like most others in the Soviet economy, have felt the pressures of taut planning and output quotas.

The Soviets' traditional emphasis on gross output has left little room for maintenance, conservation, or improved efficiency. But after years of waste and exploitation, the consequences of extensive growth practices are now too serious to ignore. The railway system is in desperate need of upgrading and repair and the energy sector requires advanced equipment and techniques to meet demand. In addition to these problems there is growing concern about the impact of industrialization on the environment. Wasteful reclamation projects have both jeopardized water supplies and damaged agricultural lands. Water and air pollution problems have become so acute in certain areas that they pose serious health problems.

Despite the urgency of these problems, the Soviet leadership faces a serious dilemma when devising investment strategies for transportation, energy, and environmental protection. Investments in these sectors, although essential, will be quite costly, and will produce few dramatic results in the short term. Because the leadership must respond immediately to so many demands, it will be tempted to continue the pattern of exploitation and neglect. The study explores the leadership's options in these sectors given historical investment patterns and current needs.

## II. TRANSPORTATION IN THE 12TH FIVE-YEAR PLAN

Soviet planners have customarily anticipated traffic growth to be lower than growth in total output; the 12th Five-Year Plan continues this practice. The growth in total volume of freight traffic is targeted at 12 to 14 percent, a rate notably lower than those intended for industrial and agricultural output. Western experts have forecast that primary energy output will increase between 11 and 15 percent from 1985 to 1990. This is associated with an increase of between 4,763 and 5,040 billion ton-kilometers of freight traffic. Added to this is the increase in nonfuel GNP which is estimated as follows:

FYP XII calls for a 19-22 percent rise in national income; if non-energy GNP were to rise to the same extent, it would be associated with from 4,998 to 5,150 billion ton-kilometers of freight traffic. The indicated range of total freight traffic required for 1990 by FYP XII is from 9,761 to 10,190 billion ton-kilometers, exceeding the planned traffic of 8,742 to 8,899 billion ton-kilometers by from 10 percent to 17 percent.<sup>1</sup>

With prospective freight transport needs exceeding plan provisions, additional strains will be placed on a transportation system already pushed to its limits. Although road shipments in trucks will account for about 80 percent of total tons shipped, truck hauls in the Soviet Union typically cover shorter distances and handle only a small percentage of intercity traffic. Rail is the favored means of transport for long distances, and railroads have been put under tremendous pressures in recent years.

Developments in other sectors of the economy, however, have kept pressures on the transportation system below those of the plan targets. Energy and industrial production, both of which demand large transport

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<sup>1</sup>Holland Hunter and Vladimir Kontorovich, "Transport Pressures and Potentials," *Gorbachev's Economic Plans, Volume II*, U.S. Government Printing Office, Washington, D.C., 1987, p. 388.

capacity, have fallen below planned levels during the 12th FYP. The current "control numbers" for shipments in 1989 are 2.5 percent below the original Gosplan five-year plan target for this year. Even if these numbers are exceeded by 1 percent, the achievement of the five-year plan target for 1990 would require a 3.3 percent increase in shipments during that year.<sup>2</sup> But although the pressures on the system, especially the railroads, have been less than anticipated, Soviet transportation seems to be faltering, and the investment allocations made during the 12th FYP have been insufficient to stop the process.

According to the plan, fixed capital investment in railroads was to increase from 24 to 28 billion rubles, comprising 26.8 percent of total fixed capital investment for transportation and communications. The allocation for oil and gas pipelines, however, would decline to 31 billion rubles with the balance for other modes (primarily for roads and trucking) dropping from 41 to 39 billion (see Table 1).<sup>3</sup>

Total investment for the transport and communications sector is just over 10 percent of aggregate national fixed investment, down from the 12.4 percent share transport received during 1981-1985. It is expected that continuing inflation will have eroded the one billion ruble increase in transport investment that was planned for the 1981-1985 period. In real terms, the transportation sector will receive less capital than before while trying to handle increased freight traffic. (See Tables 2, 3, 4.)

## CONDITION OF THE SOVIET RAILROADS

In terms of combined volume of freight and passenger traffic carried per kilometer of line, the Soviet railroads now bear the heaviest burden of any railroad system in the world. Until the 1970s the Soviets performed impressively both in upgrading their system and maximizing its utilization. But during the 1970s parts of their system became so congested that many performance indicators decreased and the

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<sup>2</sup>Vladimir Kontorovich, "Transport Performance in the First Quarter of 1989," *PlanEcon Report*, June 1, 1989, p. 15.

<sup>3</sup>Hunter and Kontorovich, p. 384.

Table 1

FIXED CAPITAL INVESTMENT IN TRANSPORT AND COMMUNICATIONS  
(In billions of 1984 rubles)

	1981-85	1986-87	1986-90(a)	Percent Share	
				1981-85	1986-90
Railroads	24.1(b)	10.7	28.2	23.1	26.8
Other	40.9		39.0	39.2	37.1
Subtotal	65.0(c)		67.2		
Pipelines	34.3		31.0	32.9	29.5
Communications	5.0(b)		7.0	4.8	6.6
Total	104.3(b)	46.8	105.2	100.0	100.0

(a) 1986-1990 estimates from Hunter and Kontorovich, p. 384.

(b) *Narkhoz za 70 let.*

(c) V. E. Biriukov in Plan Khoz, 1986.

Table 2

TRAFFIC VOLUME BY EACH MODE OF TRANSPORT  
(In billions of ton-kilometers)

Year	Total	Rail- road	Mari- time	River	Auto- mobile	Air	Pipeline	
							Oil	Gas
1960	1898.3	1504.3	131.5	99.6	98.5	0.56	51.2	12.6
1970	3960.6	2494.7	656.1	174.0	220.8	1.88	281.7	131.4
1980	6781.1	3439.9	848.2	244.9	432.1	3.09	1216.0	596.9
1985	7607.8	3718.4	905.0	261.5	476.4	3.35	1312.5	1130.6
1986	8193.0	3834.5	969.7	255.6	488.5	3.38	1401.3	1240.0

SOURCE: *Narkhoz za 70 let*, p. 341.

Table 3  
SHIPMENTS BY EACH MODE OF TRANSPORT  
(In millions of tons)

Year	Total	Rail- road	Mari- time	River	Auto- mobile	Air	Pipeline	
							Oil	Gas
1960	10,816	1,885	76	210	8,493	.7	130	21
1970	18,522	2,896	162	358	14,623	1.8	338	143
1980	29,626	3,728	228	568	24,149	3.0	627	323
1985	31,819	3,951	240	633	25,879	3.2	631	482
1986	33,133	4,078	250	649	26,985	3.2	653	515
1987 (plan)	33,124	4,050	248	650	26,982	3.1	653	538

SOURCE: *Narkhoz za 70 let*, p. 340.

tracks themselves began to deteriorate. From 1978-1982 the railroads caused serious bottlenecks in the surrounding economy. In 1982 N. S. Konarev replaced Ivan G. Pavlovskii as the Minister of Railroads and launched a recovery through a harsh disciplinary campaign. The main goal at this time was to raise the average gross weight of freight trains by increasing the number of cars per train. Heavier trains meant fewer trains for any given volume of shipments and this became the key to relieving congestion. The 1983 gains in average train weight and speed improved train productivity. Turnaround time was cut and daily car runs lengthened. In 1983 traffic density resumed its upward trend with less overcrowding of the rail lines through 1984 and 1985.

The recovery in the 1983-1985 period was the result of increased effort rather than improvements in railroad capital plant and equipment and this approach to problem solving has its limitations. Konarev seems to have recognized these limitations and on several occasions has requested greater investment for the railroad system. Unfortunately, the greatest pressures for increasing traffic are on lines that are already the most utilized. D. K. Zotov, the head of Gosplan's transport department, cited a study in 1986 that revealed 50 percent of the

Table 4  
PLANNED 1990 FREIGHT TRAFFIC, USSR

Freight Traffic	Low 1990	High 1990	Percent Increase	
			Low 1990	High 1990
Billions of Ton-Kilometers				
Railroads	4,046	4,140	8.8	11.4
Oil pipelines	1,379	1,412	5.1	7.6
Gas pipelines	1,469	1,494	29.9	32.2
Maritime	996	996	10.0	10.0
Trucks	562	567	18.0	19.0
Rivers	285	285	9.1	9.1
Air	5	5	16.8	33.0
Total	8,742	8,899	12.0	14.0
Millions of Tons Originated				
Railroads	4,300	4,400	8.8	11.4
Oil pipelines	663	697	5.1	7.6
Gas pipelines	626	637	29.9	32.2
Maritime	264	264	10.0	10.0
Trucks	30,530	30,789	18.0	19.0
Rivers	691	691	9.1	9.1
Air	4	4	16.8	25.0
Total	37,078	37,464	16.6	17.8

NOTE: Estimates done by Hunter and Kontorovich. Increase over 1985 statistics.

network was already working at above capacity levels with another 14 percent at full capacity. The area of greatest concern is the eastern regions where demand has been growing most rapidly and under the 12th Five-Year Plan is targeted to grow 50 percent higher than elsewhere.

The most recent reports from the Soviets indicate that railway transport is once again slowing down. In 1987 annual freight shipments by rail declined 0.2 percent from 1986. Railway shipments recovered in

1988 but this was due almost completely to growth in shipments during the first quarter of the year. Growth in rail freight shipments stagnated in the second quarter of 1988 and has continued this pattern through the first quarter of 1989. The level of shipments in 1989 has been only 1.3 percent higher than three years ago.<sup>4</sup> Because of the growing demand on an already overworked and aging system, real growth in railroad capacity and productivity will require Herculean efforts on the part of the Soviets. Soviet planners face a vicious cycle when they attempt to break the bottlenecks in the railways. The railroads, with their current carrying capacity and under the current system of management, are clearly inadequate to meet the needs of the Soviet economy. The tracks and rail cars are old, workers are in short supply, and the level of maintenance is low. To compensate for limited capacity, the managers have forced the system to work harder. This, of course, wears the physical assets out faster, gives incentives for workers to seek jobs in other areas, and increases the necessary levels of maintenance and repair. With fewer workers, fewer repairs are made and the system deteriorates at an ever increasing rate. A detailed discussion of these problems appears in the following subsection.

#### **THE BIGGEST CONSTRAINTS ON ECONOMIC GROWTH--RAILROAD CAPACITY AND MAINTENANCE**

Since 1983 the Soviet railway system has had to accommodate the demands of a relatively slow growing economy. But meeting even modest increases in demand for shipments has been difficult. Although the railroads have managed to transport most high priority freight, there are still problems in shipping low priority items. Even after the 1983 recovery, the railways have experienced bad years and in 1985 and 1987 these problems seriously disrupted the economy. Evidence indicates that Soviet railways suffer not from simple mismanagement but from real capacity constraints. The most important are listed below.

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<sup>4</sup>Kontorovich, June 1, 1989, p. 4.

**Stations.** According to a report from July 1988, more than 200 key stations are now restricting the flow of traffic.<sup>5</sup> They are unable to handle the increased traffic and in many stations the length of heavy trains exceeds the length of tracks. Trains must wait to enter stations or slow down to pass them and this often negates any time saved through higher train speed on the line. Many stations accommodate only 57 car trains instead of the 70 or more cars required for the heavy trains. Transit or assembly of heavy trains requires special effort and may disrupt regular traffic.<sup>6</sup>

**Railway Lines.** Much of the 1983 recovery was brought about by increased use of fewer but heavier trains. This method of enhancing train productivity, however, appears to be exhausted and increases in train weight have slowed. The target of 3,500 ton average weight by 1990 is clearly unattainable but this is reportedly the minimum capacity necessary for stabilizing the function of the railways.<sup>7</sup>

Another means of increasing rail line capacity has been the installation of automatic block signaling and centralized dispatcher control. These procedures allow shorter intervals between trains going in the same direction. Unfortunately on the most heavily traveled lines, time intervals have already been cut to the minimum. Six minutes between trains is the shortest time required, and railways that implemented this interval actually experienced a decline in train speed and greater rather than less congestion.<sup>8</sup>

Despite the successful efforts at reducing traffic on the rail lines, congestion is increasing once again and will probably choke off the current modest increases in productivity.

**Rolling Stock.** Almost half of the locomotives are more than 20 years old and one-quarter are older than 30 years.<sup>9</sup> One-third of

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<sup>5</sup>Vladimir Kontorovich, "Transport Performance in the First Six Months," *PlanEcon Report*, August 1988, p. 9.

<sup>6</sup>Kontorovich, August 1988, p. 10.

<sup>7</sup>Kontorovich, August 1988, p. 8.

<sup>8</sup>Kontorovich, August 1988, p. 8.

<sup>9</sup>Vladimir Kontorovich, "Transport Performance in the First Quarter 1988", *PlanEcon Report*, May 1988, p. 16.



locomotives are worn out and their current repairs cost several hundred million rubles annually.<sup>10</sup> The total number of breakdowns of locomotives has increased. In addition, there is a shortage of freight cars, estimated at several tens of thousands. About one-fifth (280,000) of the total stock of freight cars are worn out.<sup>11</sup>

Problems extend to passenger service as well. Shortages of both passenger cars and locomotives exist and the share of obsolete and worn out cars recently has increased. The ministry has no long-term program for improving the standards of passenger service, even though the conditions on passenger trains are very bad. On April 2, 1987, *Izvestiya* reported:

The railroads frequently fail to observe requirements regarding preparing and maintaining cars in proper condition for trips. Cars with defective heating and water supply systems or sanitary-technical equipment are frequently coupled to passenger trains. There have been instances when temperature in passenger and suburban train cars has dropped below zero.<sup>12</sup>

**Track and Other Structures.** In the 1960s, the condition of tracks was actually improving. The total number of discovered defects declined and the number of derailments was stable. Conditions began to deteriorate in the 1970s. Between 1971 and 1986, the number of discovered defects almost doubled and derailments increased 3.7 times. Deterioration of track has continued through 1988.<sup>13</sup>

This has taken place despite efforts to improve the average weight of rails on the main lines. Given current traffic density, the average weight of rails should be 63-66 kg/cm. The actual weight is closer to 61 kg/cm, but this is a substantial improvement over the statistics from the 1970s, when the gap between actual and required weight was much

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<sup>10</sup>Kontorovich, August 1988, p. 12.

<sup>11</sup>Kontorovich. August 1988, p.12.

<sup>12</sup>"Railroad Ministry Not Meeting Demands," *Izvestia*, April 2, 1987, in *USSR National Affairs Political and Social Developments*, April 8, 1987, p. 2.

<sup>13</sup>Kontorovich, August 1988, p. 13.

larger.<sup>14</sup> Currently, two-thirds of freight traffic is carried on thermally strengthened rails and one-half on welded rails with ties of reinforced concrete. These improvements were practically nonexistent in 1960.<sup>15</sup>

The process of upgrading tracks, however, has not matched the increase in traffic. Some of the tracks that carry heavy modern trains have not been reconstructed since 1938 or even 1913. A large number of bridges have been in use for 100-120 years. The number of defective bridges has declined by 19 percent since 1983 but those with structural flaws threatening breakdown have increased by 40 percent.<sup>16</sup> This problem is exaggerated by the decline in quality of new construction. The newer bridges exhibit fatigue cracks very early and require extensive maintenance.

Maintenance is also a factor in overall conditions. Although engineers do establish standards for the maximum traffic a line can carry before needing repair, these standards are increasingly ignored. The amount of track exceeding the maximum has increased to 30,000 km.<sup>17</sup> At the current rate of repair, it would take 66 years to handle the backlog of delayed track repairs. Plans for replacement and repair are perennially underfulfilled.<sup>18</sup>

The reasons for inadequate maintenance are chronic supply deficits, squeezed funding and resource allocation, and shortages of labor. In 1986-1987, rail supplies were 140,000 tons short of the planned amount, switches are chronically 35-40 percent short of demand, and ties and other supplies are often unavailable. The labor shortage is also felt throughout the system. One report claims that 30 percent of track maintenance positions are vacant; another estimates 20 percent of all positions in track services are empty with much larger percentages, 70-75 percent in some cases, for track maintenance workers. The Railroad Ministry officially reports that there is a shortage of 3,000

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<sup>14</sup>Kontorovich, August 1988, p. 13.

<sup>15</sup>Kontorovich, August 1988, p. 13.

<sup>16</sup>Kontorovich, May 1988, p. 17.

<sup>17</sup>Kontorovich, August 1988, p. 14.

<sup>18</sup>Kontorovich, August 1988, p. 14.

track engineers, but according to V. Sablin, a lecturer at the Rail Transport Electromechanical Institute in Sverdlovsk, the actual shortage is much greater.<sup>19</sup>

**Safety.** One sure signal of all the above mentioned problems is deteriorating safety. Unfortunately, the attempt to expand productivity by pushing the system to its limits has made the railroads much more prone to breakdowns and accidents. The incidence of trains failing to stop at red signal lights has been increasing and over half of these failures have been due to engineers falling asleep. This phenomenon is explained by the disruptions in train movement resulting from congestion, low maintenance, and poor work organization, forcing railroad crews into working overtime. The working conditions of locomotive engineers routinely violate both Soviet labor law and requirements for safe operation.<sup>20</sup> A. Godunko in an interview in *Sovetskaya Rossiya* on August 9, 1988, criticized railway workers for excessive drinking and other careless attitudes toward work but also admitted that the conditions of the workers were far from satisfactory.

To be fair, one must also say that the person who commits professional error is not always to blame. We know that the laws on work and rest are frequently broken. On all the railways of the RSFSR, the overtime norms are exceeded by 2-3 times. Moreover, overtime which leads to the exhaustion of drivers and their assistants is by no means worked only in exceptional circumstances, but simply because of failings in the organization of transport. I would add that normal conditions for railway-workers to relax exist by no means everywhere.<sup>21</sup>

Accidents resulting from defects in the track have also become more frequent. This is hardly surprising given the shortage of maintenance workers and the need to concentrate limited resources on the major lines. Railway stations, especially the smaller ones, receive almost no

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<sup>19</sup>"Soviet Railways: Results of Neglect," *Soviet Analyst*, August 31, 1988, p. 4.

<sup>20</sup>Kontorovich, August 1988, p. 11.

<sup>21</sup>"Soviet Railways," p. 5.

attention and they are the sites of the majority of derailments resulting from defective track.<sup>22</sup> Sablin claims that 40 percent of all rail emergencies are caused by faults in the track and that there are 29,000 defective rails in the Sverdlovsk area alone, with hundreds of thousands in the country as a whole.<sup>23</sup>

The increase in accidents has attracted the attention of the party leadership and the Ministry of Railroads has issued restrictions on assembling double trains. Because few trains can satisfy the requirements, fewer double trains are now being dispatched. In June 1988, the Deputy Minister of Railways, Gennadiy Kozlov, held a press conference on railway safety during which he claimed the "laxity, undiscipline and criminal negligence by workers" was largely responsible for the situation. But in its report on the press-conference on June 25, TRUD reported some startling statistics about the Soviet railway system.

Today more than a third of locomotives are electric, while 25 percent of the diesel locomotives are obsolete, having been in operation 20-30 years. In the last 10 years, the average breakdown rate of rail wagons has doubled. Some tens of thousands of electric traction units need to be replaced, and 30,000 km of track fail to receive regular maintenance--in other words they pose an increased danger. About 130,000 radio transmitters used by drivers and station workers are obsolete and worn-out and only 30 percent of the demand for replacements is being met. The technical state of the sector is causing understandable alarm.<sup>24</sup>

According to Kozlov, since 1965 an average of 60 people have died in crashes on Soviet railways. 1987 was a particularly bad year with 157 dead, largely as a result of the the accident at Kamenskaya where 106 people died.<sup>25</sup>

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<sup>22</sup>Kontorovich, August 1988, p. 15.

<sup>23</sup>"Soviet Railways," p. 4.

<sup>24</sup>"Soviet Railways," p. 4.

<sup>25</sup>"Soviet Railways," p. 4.

**Investment.** Investment for the railroads suffers from two problems, insufficient funds and insufficient supplies. Minister Konarev has stated that planned investment for 1988 is insufficient in both rolling stock and equipment and structures. The 12th Five Year Plan emphasized double tracking and electrification at the expense of slower construction of new lines but currently targets are not being met (see Table 5).

Total volume of railroad investment planned for 1988 is 7.06 billion rubles for both productive and nonproductive investment (housing, etc.). The state budget finances 40 percent of this sum, or 2.8 billion rubles destined for new construction.<sup>26</sup>

Data on construction, however, must be viewed with some skepticism. Many of the lines electrified between 1977 and 1983 are still not fully operational and neither are many of the recently built and double tracked lines. One of the most acute shortfalls is in construction of worker housing. In January 1987, TRUD reported that about 500,000 rail workers' families needed housing, yet the Ministry of Railways had failed to assimilate over R120 million allocated for this purpose. As a result, 204,000 square meters of planned housing had not been constructed.<sup>27</sup>

Table 5

COMMISSIONING OF NEW LINES, SECOND TRACKS, ELECTRIFICATION, AND  
AUTOMATIC BLOCK  
(In kilometers per year)

Installations	12th FYP Average	1986-88 Average	1986	1987	1988 Plans
Electrification	1600	1520	2109	1144	1300
Double tracking	800	627	694	603	586
New line	460	571	548	622	544
Automatic block	n.a.	n.a.	n.a.	1338	1230

SOURCE: "Net Stroek 'nevyhodnykh,'" *Gudok*, April 23, 1988.

<sup>26</sup>Kontorovich, August 1988, p. 16.

<sup>27</sup>TRUD, January 20, 1987, p. 2, in Joint Publications Research Service, *Soviet Union, Economic Affairs*, February 13, 1987.

Part of the problem in fulfilling targets is the availability of investment goods. In 1987, supplies of electric locomotives fell short of the plan target by 137 units, mainline diesel-electric locomotives by 76, freight cars by 1,400, and passenger cars by 186. As a result of these and other shortfalls, the transportation sector has difficulty assimilating even the current low levels of investment.

In terms of investment required to improve the railway system, the Soviets estimate 3 billion rubles will be required to bring track levels up to standard for current loads and catch up with delayed maintenance and repair. Construction should be targeted on structures (rather than on rolling stock) and concentrated in the eastern regions.<sup>28</sup>

According to the projection of VNIIZht, the main research establishment of the Ministry of Railroads, traffic is expected to increase by 450-480 billion tons over the next 15 years. Normal functioning of the railroads will require 1.5 times the volume of investment of the 12th Five-Year Plan.<sup>29</sup>

## MOTOR VEHICLE TRANSPORTATION

The use of trucks for local transport grew rapidly during the 1970s with annual growth rates between 5 and 10 percent. The speed and convenience of trucks for local delivery of finished goods should assure continued growth in this sector. The growth rates in the 1970s, however, gave way to absolute declines in 1983-1985 as the average length of haul stabilized and the tons shipped actually declined (see Table 6). This phenomenon apparently does not reflect a decline in demand for motor vehicle transport. The Ukrainian Minister of Automobile Transport claims that only 45 percent of demand for intercity services is being met while demand for local services is even greater.<sup>30</sup>

There are two possible explanations for the decline. The first is that shortfalls in gasoline and diesel fuel production have restricted truck transport. The second is that automotive transport has been

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<sup>28</sup>Kontorovich, May 1988, p. 27.

<sup>29</sup>Kontorovich, May 1988, p. 27.

<sup>30</sup>Hunter and Kontorovich, p. 388.

typically over-reported. Estimates for the RSFSR exaggerate actual volume of traffic by at least 20 percent.<sup>31</sup> Late in 1982, a campaign for tightening discipline may have cut the degree of over-reporting. Complaints about inflated reports, however, were as frequent in 1985 as they had been before the campaign.

Because both weight of shipment and length of haul can be over-reported, traffic volume (measured in ton-kilometers) should have declined more than shipments (measured in tons originated). The official statistics, however, indicate that declines in 1983-1985 were greater for shipments than for traffic. In 1986 common carrier truck shipments rose again but the causes of the recovery are as unclear as those of the preceding decline.<sup>32</sup>

Automotive transport suffers from some fundamental problems in the production of equipment. A. S. Yeliseyev, Rector of Moscow's Bauman Higher Technical School, has stated that only 29 percent of Soviet motor vehicles measure up to world standards. As examples he cites the fact that the engines on KamAZ trucks run 170,000-180,000 km before overhaul

Table 6  
TRUCK TRAFFIC, USSR

Year	Tons-Kilometers (billions)	Tons Originated (millions)	Average Hauls (kilometers)
1970	221	14,623	15.1
1980	432	24,149	17.9
1981	460	25,016	18.4
1982	485	26,481	18.3
1983	486	26,425	18.4
1984	475	25,631	18.5
1985	477	25,879	18.4
1986	489	26,985	18.1

SOURCE: Annual *Narkhoz* volumes.

<sup>31</sup>Hunter and Kontorovich, p. 389.

<sup>32</sup>Hunter and Kontorovich, p. 389.

while comparable Mercedes Benz trucks will run 700,000-800,000 km. The Japanese Kamatsu dump trucks used by the Ministry of Coal Industry have a life three to five times longer than BelAZ trucks of the same size.<sup>33</sup>

The automotive sector utilizes a large amount of foreign capital goods. During the 11th Five-Year Plan about 2 billion rubles worth of imported equipment was purchased for the Ministry of the Automotive Industry.<sup>34</sup> The 12th Five-Year Plan also includes substantial purchases of imported equipment and foreign licenses. The heavy reliance on foreign technology seems to stem from the poor return on domestic Soviet research and development funds. According to an article in *Izvestia* April 30, 1987:

Last year the yield from the application of research results amounted to 1.9 rubles per ruble spent. That is significantly lower than in the machine-building complex as a whole where the figure is 2.3 rubles. At the Gorky automotive Plant Production Associate, however, the return on each ruble spent averages 70-90 kopecks. In other words, the work of factory researchers there yields nothing but losses.

Problems extend not only to the truck fleet itself but also to its utilization. According to an article in *Pravda* published in February 1989, more than one-third of all trucks do not work on any given day and of those that do work, only about six hours per day are spent on the road. Almost half the hauls are empty and when the trucks are in fact loaded, they carry less than their capacity.<sup>35</sup>

## TRANSPORT TOWARD THE YEAR 2010

The high and medium estimates for expenditure on transport and communications were computed on the basis of the following observations and assumptions:

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<sup>33</sup>"An Industry on Economic Accountability," *Izvestia*, April 30, in *Current Digest of Soviet Press*, Vol. XXXIX, No. 17, 1987, p. 17.

<sup>34</sup>*Izvestia*, April 30.

<sup>35</sup>Kontorovich, June 1989, p. 17.



1. The official expenditure statistics for 1986 and 1987 indicate higher rates of capital investment in transportation than originally projected for the 12th FYP, although investment in railroads is close to the projection. Overall investment plans for the period, however, have proven too ambitious, largely because of labor shortages. Centralized funding for investment in all sectors has been cut back from the planned levels for 1989-1990.
2. Investment in the transportation and communications sector has, on average, constituted about 11 percent of total capital investment since 1960. The rate rose to 12.4 percent in the 1981-1985 period but has fallen to 11.7 percent in the 1986-1987 period.<sup>36</sup>
3. Growth in fixed capital in the transportation and communications sectors through the 1980s has been at a rate similar to growth in other sectors of the economy.
4. Growth in operating capital over the 11th FYP was roughly 24 percent. The 1986 statistics indicate an increase of about 4 percent over the 1985 expenditure; the 1987 figure is about 6 percent higher than 1986. A substantial percentage of the operating capital figure goes toward maintaining stocks and inventories. In general the statistic represents expenditures on supplies necessary to keep the enterprises functioning.
5. The transport sector suffers from typical Soviet inefficiency. A study of the Soviet petroleum industry indicated that improved planning could reduce the need for transport by up to 14 percent.<sup>37</sup> Elimination of empty hauls and improvement in dispatching transport vehicles could substantially decrease costs throughout the transportation sector.

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<sup>36</sup>*Narodnoye Khozyaustvoe, Iubileinyi Statisticheskii Ezhegodnik, 1987, Financi i Statistiki, Moscow, 1988, pp. 294-295.*

<sup>37</sup>"Effect of Transport Service on Oil Production," in Joint Publications Research Service, *Soviet Union, Economic Affairs*, November 2, 1988, p. 13.

6. Most of the planned increase in transport comes from an increase in the volume shipped rather than in the distances shipped. The greatest increases are in the volumes transported through pipelines. Pipelines, however, transport only a small percentage of total shipments. According to the projections done by Hunter and Kontorovich, the percentages of total shipments carried by various modes of transportation will stay fundamentally constant: That is, there is no planned shift from one mode of transport to another. The railroads remain the most important mode of long-distance shipping.

7. Official Soviet statistics have traditionally reported low rates of depreciation for capital goods. This has led to lower rates of replacement than is desirable. Even though replacement rates have been higher recently they are well below what is necessary. Overall growth in the capital stock in transportation and communication was 86 billion rubles during 1981-1985. This compares to 104.3 billion rubles in capital investment in this sector during the period.<sup>18</sup> Although capital investment statistics do include labor cost for new construction and installation, they do not include the cost of major repairs to fixed capital in the transportation and communication sector (see Table 7). During the 11th FYP period an additional 34.72 billion rubles were spent in capital repair.<sup>19</sup> The increase in capital repair cost over this period was between 5-7 percent per year.

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<sup>18</sup>*Narodnoye Khozyaustvoe za 70 let, Iubileinyi Statisticheskii Ezhegodnik*, Financi i Statistik, Moscow, 1987.

<sup>19</sup>*Narkhoz*, 1985, p. 558.

Table 7

DEPRECIATION DEDUCTIONS FOR TRANSPORTATION AND COMMUNICATION  
(In millions of rubles)

	1970	1980	1985	1986	1987
Total depreciation	5,410	12,454	17,132	18,350	19,102
Including capital repairs	3,196	5,936	7,638	8,090	8,369

SOURCE: *Narkhoz za 70 let*, p. 626, *Narkhoz, 1987*, p. 585.

The medium estimate for transportation and communications expenditure uses as a base the 12th FYP fixed capital expenditure estimated by Hunter and Kontorovich (105.2 billion rubles). Because the expenditure statistics from 1986 seem consistent with this estimate it provides a fairly reasonable base statistic. If the Soviets invest all that is recommended by VNIIZht, the fixed capital investment in the railroads would be 1.5 times the level specified in the 12th FYP.<sup>48</sup> The medium estimate for total expenditure for transportation and communications including operating capital and capital repair is 295.91 billion rubles (see Table 8).

The low estimate is calculated the same way as the medium estimate but holds investment in railroads constant. This yields a total of 281.8 billion rubles in expenditure for 1991-1995.

<sup>48</sup>Multiplying 28.2 billion rubles by 1.5 yields 42.3 billion rubles for capital investment in 1991-1995. All other sectors of transport and communications are held at constant rates (again consistent with the expenditures forecast under the 12th FYP). This would constitute additional fixed capital funds of 77 billion rubles (total fixed capital investment at 119.3 billion rubles). To this number is added the operating capital expenditures for transport and communications. If one takes a 5 percent increase in operating capital per year over the 12th FYP period, total operating capital expenditure for this period would be 90.7 billion rubles. Assuming that the 5 percent increase continues through 1991-1995, the total operating capital expenditure for this period would be 115.56 billion rubles. Adding this figure to the fixed capital expenditure yields a figure of 234.9 billion rubles. With an estimated increase of 6 percent per year in capital repair costs, total capital repair during 1991-1995 will be 61.05 billion rubles.

Table 8  
TOTAL EXPENDITURES FOR TRANSPORTATION AND COMMUNICATION  
(In billions of rubles)

	1981-85	1986-90	1991-95		
			High	Medium	Low
Capital investment	104.3	105.2	125	119	105
Operating capital	71.4	90.97	116	116	116
Capital repair	24.72	46.6	65	61	61
Total	210.42	242.77	306	296	282

NOTE: Estimates have been rounded to the nearest billion.

The high estimate assumes that growth in railway investment will be 1.5 times the rate projected under the 12th Five-Year Plan, but investment in the other areas of transportation will return to the levels of the 11th Five-Year Plan (80 billion rubles for the 1981-1985 period). The growth in operating capital will remain at the same 5 percent per year level but the growth in capital repair expenditures will increase to 8 percent per year.

Estimates for expenditures in 1995, 2000, and 2010 are based on the same assumptions as above. The 1995 statistics are derived from the total numbers for the 1991-1995 FYP. Expenditures in 1995 are then used to project spending in 2000 and 2010. The medium estimate for the year 2000 assumes that capital investment will increase at a rate of 4 percent per year over the medium statistic for 1995. This yields expenditure of 30 billion rubles. Operating capital is assumed to grow at 5 percent per year and capital repair at 6 percent per year. These numbers are 32 billion rubles and 19 billion rubles, respectively. The low estimate assumes an increase of 3 percent per year in capital investment over the low 1995 expenditure. This figure is 26 billion rubles. Operating capital increases at 4.5 percent per year and capital repair increases at 5.5 percent per year over the low 1995 figure. The high estimate has the same growth rates as the medium estimate for

capital investment and operating capital but uses the high 1995 figure as the base statistic. Capital repair grows at 8 percent per year.

The medium estimates for 2010 assume a 50 percent growth in fixed capital investment over the 15 years following 1995 with growth in operating capital at 5 percent per year and growth in capital repair at 6 percent per year. The low estimate assumes a 40 percent increase in fixed capital investment with growth in operating capital and capital repair at slightly below the medium levels. The high estimate assumes a 60 percent increase in fixed capital investment with operating capital at the medium estimate levels and capital repair growing at 8 percent per year.

#### DEFLATING THE STATISTICS--1982 AS A BASE

The estimated expenditures on Soviet transportation and communication are derived from investment figures in the statistical yearbooks. These figures are reported in estimate prices which is a term denoting several sets of parameters:

1. Prices of all inputs into the project under construction (wholesale prices of industrial goods and services, transport tariffs, expenditures on operation of construction machinery, wage rates, and surcharges of supply organization).

Table 9

TOTAL EXPENDITURES FOR TRANSPORTATION: 1995, 2000, AND 2010

	1995			2000			2010		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
Fixed capital investment	28	25	22	34	30	26	45	42	32
Operating capital	25	25	25	32	32	31	52	52	50
Capital repair	15	14	14	22	19	18	36	33	30
Total	68	64	61	88	81	75	133	127	112

2. Overhead rates and profitability rates in construction.
3. Price lists for installation work.
4. Input coefficients, defining the maximum amount in input that may be spent per unit of a particular construction.<sup>41</sup>

The method of converting current prices into estimate prices is not explained in the yearbooks, but there are references in Soviet literature to an "index of investment" or "transitional coefficient" which is the estimate price index used to make the transformation. In general, the estimate price index is calculated by dividing the volume of investment in actual prices by the same volume in estimate prices of the base year.<sup>42</sup> Separate indices are compiled for various elements of investment: construction and installation work, equipment requiring installation, equipment not requiring installation, and design and survey work.<sup>43</sup>

A question remains as to whether these estimate prices actually deflate the current price statistics. Although estimate prices are supposed to remain constant between revisions, they are in fact changed in accordance with official price changes. Estimate costs, which use estimate prices to establish needed financing for investment projects, are also routinely revised upward. The result of these price-cost revisions is summed up by Kontorovich and Rumer:

If official price changes make the actual cost diverge from the estimate cost, concealed price changes are ratified by increasing the estimate cost. Estimate prices and estimate costs are far from being fixed, they are subject to full impact of hidden inflation in the sectors producing investment goods and services.<sup>44</sup>

Kontorovich and Rumer conclude that inflation in the investment statistics is a serious possibility. Although some experts in the Soviet economy prefer to work with the Soviet statistics as they are

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<sup>41</sup>Vladimir Kontorovich and Boris Rumer, *Inflation in the Soviet Investment Complex*, report by Command Economies Research Inc., May 1988, p. 11.

<sup>42</sup>Kontorovich and Rumer, p. 24.

<sup>43</sup>Kontorovich and Rumer, p. 10.

<sup>44</sup>Kontorovich and Rumer, p. 22.

published, the estimates in this study were deflated to constant 1982 rubles. The choice of a deflator was somewhat arbitrary given what little is known about problems of inflation in the Soviet Union.

Several Soviet economists, as well as the Stroiibank, have studied inflation in Soviet investment. Although there are some substantial differences in opinion concerning inflation in the 1971-1975 period, the rates from the mid 1960s through 1983 average around 3 percent per year.<sup>45</sup> Recent reports on inflation in the Soviet Union indicate that inflation rates have increased during the 1980s. Estimates vary according to whether investment or retail prices are being considered, but inflation, both open and hidden, is acknowledged by many analysts to be a problem throughout the economy. Maya Shukhgal'ter in her research on capital stocks suggests inflation allowances of 14-27 percent.<sup>46</sup> Gosplan reports repressed inflation in retail prices in 1989 at 5.5 percent.<sup>47</sup> Because inflation is such a pressing problem in the USSR the authors have chosen to deflate the projections made from the official Soviet statistics. A deflator assuming a 5 percent inflation rate was used to modify the nominal ruble projections to 1982 rubles (see Table 10). Although this number is not taken from any official sources, it nevertheless falls within the range of projections currently being suggested.

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<sup>45</sup>Kontorovich and Rumer, pp. 41, 57.

<sup>46</sup>Maya Shukhgal'ter, "Capital Stock in the USSR and USA: Problems of Comparison," presented at American Enterprise Institute Conference, April 1990.

<sup>47</sup>Central Intelligence Agency and Defense Intelligence Agency, "The Soviet Economy Stumbles Badly in 1989," presented to the Technology and National Security Subcommittee of the Joint Economic Committee, U.S. Congress, April 20, 1990.

Table 10

TOTAL EXPENDITURES FOR TRANSPORTATION AND COMMUNICATION  
(In billions of 1982 rubles)

	1995(a)			2000(b)			2010(c)		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
Fixed capital investment	15	13	12	14	13	11	12	11	8
Operating capital	13	13	13	13	13	13	13	13	13
Capital repair	8	8	7	9	8	8	9	8	8
Total	36	34	32	36	34	32	34	32	29

(a) Deflator for 1995 = 1.9.

(b) Deflator for 2000 = 2.4.

(c) Deflator for 2010 = 3.9.



### III. ENERGY

For purposes of constructing our final demand estimates, final demand for the energy sector can be divided into investment in the fuels and electricity sectors and retrofit of nuclear facilities.

#### INVESTMENT IN THE FUELS AND ELECTRICITY SECTORS

Ruble investment in 1985 in the power, coal, and oil/gas sectors was, respectively, 6,664, 2,905, and 15,684 million rubles. With an assumed inflation rate of 5 percent for the relevant time period, these figures become 5,757, 2,509, and 13,548 million 1982 rubles, respectively, summing to 21,814 million 1982 rubles. Reasonable high, medium, and low real growth rates for such investment can be assumed to be 10 percent, 5 percent, and 2 percent per year, respectively. Table 11 presents the resulting investment figures for fuels and electricity during 1990 through 2000.

#### NUCLEAR SAFETY RETROFIT

At a time that production costs for conventional fuels usable for thermal electricity generation have grown substantially, both the importance and the cost of the Soviet nuclear program have increased as well. The cost increase is due in no small part to safety concerns

Table 11  
INVESTMENT IN FUELS AND ELECTRICITY SECTORS  
(In billions of 1982 rubles)

Year	High	Medium	Low
1990	35.1	27.8	24.1
1995	56.6	35.5	26.6
2000	91.1	45.4	29.4

greatly enhanced in the wake of the Chernobyl disaster of April 1986. This has been illustrated by the cancellation of Chernobyl units 5 and 6, which were to have achieved commercial operation in 1991 and 1992, respectively. The accident has increased the perceived value and importance of containments around nuclear reactors--particularly graphite reactors--and has raised the possibility of replacement of existing graphite reactors with light water reactors similar to the pressurized- and boiling-water types predominant in the West.

Few, if any, Soviet reactors have full containments. Thus, a "high" cost projection might assume construction of containment buildings around all existing reactors, combined with replacement of all graphite reactors by light water nuclear steam supply systems.<sup>1</sup> A medium assumption might be replacement of, say, half of the graphite reactors and construction of containments around all remaining graphite reactors and half of all others. A low assumption is construction of containments around existing graphite reactors only.

Except for six small graphite reactors operated by the Ministry of Medium Machine Building, most Soviet nuclear power plants are operated by the Ministry of Nuclear Power and are of four types: graphite liquid metal fast breeders, pressurized water, and boiling water. Most units are in the range of 400 MW to 1,000 MW, with a few either smaller or larger. There are 42 units in commercial operation, of which 16 have graphite reactors.<sup>2</sup> U.S. data indicate that a containment for a 1,000 MW unit costs about \$100 million, whereas a similarly sized nuclear steam supply system of a light water variety costs about \$125 million.<sup>3</sup> A containment for an existing graphite reactor would cost somewhat more because of its substantially greater height; let us assume \$125 million as a crude approximation.

This means that the high projection would cost about \$100 million, as a very rough average, for each of the 26 nongraphite units, and \$250 million for each of the 16 graphite units, over some unspecified period. This totals \$6.6 billion, or, perhaps, \$600 million per year between

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<sup>1</sup>This is a very high estimate in that the graphite reactors are used in part for the Soviet weapons program.

<sup>2</sup>*Nuclear News*, February 1989.

<sup>3</sup>*Phase VIII Update, 1986, Report of the Energy Economic Data Base Program*, U.S. Department of Energy, DOE/NE-0079, December 1986.

1990 and 2000. The medium projection--replacement of eight graphite reactors and construction of containments around the eight and half of all other reactors--would cost about  $8(\$125 \text{ million}) + 8(\$125 \text{ million}) + 17(\$100 \text{ million}) = \$3.7 \text{ billion}$ , or about \$336 million per year. The low projection--construction of containments around the graphite reactors--would cost about \$2 billion, or about \$180 million per year.

Using a crude 1976 Soviet-weighted ruble/dollar ratio of about 0.75, these figures become R5.0 billion, R2.8 billion, and R1.5 billion, respectively.<sup>4</sup> These are in 1976 rubles; again assuming an inflation rate of 5 percent, we obtain figures of R6.7 billion, R3.8 billion, and R2.0 billion for the high, medium, and low estimates, respectively, in "1982" rubles. If these investments are spread evenly over the 1990-2000 period, cumulative resource consumption--ignoring interest--in the energy sector would rise in 1990, 1995, and 2000 by the amounts shown in Table 12.

Table 12

CUMULATIVE NUCLEAR RETROFIT COSTS  
(In billions of 1982 rubles)

Year	High	Medium	Low
1990	0.6	0.4	0.2
1995	3.7	2.1	1.1
2000	6.7	3.8	2.0

<sup>4</sup>Imogene Edwards, Margaret Hughes, and James Noren, "U.S. and USSR: Comparisons of GNP," and James Grant "Soviet Machine Tools: Lagging Technology and Rising Imports," *Soviet Economy in a Time of Change, A Compendium of Papers Submitted to the Joint Economic Committee Congress of the United States*, Volume 1, U.S. Government Printing Office, Washington, D.C., 1979, pp. 379, 570.

## A SUMMARY AGGREGATION

A combination of Tables 11 and 12 yields the aggregated high, medium, and low projections of resource use in the energy sector during the period through the year 2000, as shown in Table 13.

Table 13

### ENERGY SECTOR RESOURCE USE (In billions of 1982 rubles)

Year	High	Medium	Low
1990	35.7	28.2	24.3
1995	60.3	37.6	27.7
2000	97.8	49.2	31.4

#### IV. ENVIRONMENTAL ISSUES AND RESOURCE DEMANDS IN THE SOVIET ECONOMY

Historically, environmental concerns have had a very low priority in Soviet planning. As an underdeveloped nation with abundant natural resources, the Soviet Union has been able to rely on extensive rather than intensive growth to achieve its economic goals. But as resources have become more expensive and the effects of waste and pollution more apparent, the Soviets have developed a greater consciousness of the need for environmental protection. This consciousness, however, goes through cycles and following a rash of environmental legislative activity in the 1970s, enthusiasm for these issues waned in the early 1980s. Mikhail Gorbachev has recently renewed the Party's focus on the environment and the Soviets do appear to have committed themselves to greater investment in environmental protection. The cyclical nature of this commitment, however, makes these investment plans among the most uncertain parts of the budget. Some of the proposed investment is clearly urgent and any delay will only mean greater cost in the future. The Soviets' stated goals for environmental cleanup, however, seem quite ambitious and probably impossible to achieve given projected expenditures and the pressures being exerted by other sectors of the economy.

##### WATER SUPPLY

The most industrialized and densely populated areas of the Soviet Union unfortunately do not have ready access to fresh water supplies. The western portions of the country account for 80 percent of industrial output but contain only 24 percent of the USSR's fresh water. The arid southern regions constitute 27 percent of the USSR's land mass but receive only 2 percent of the total fresh water.<sup>1</sup> Because water supply is such an acute problem in most of the developed portions of the USSR, improved conservation and water recycling are critically important.

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<sup>1</sup>Craig Zumbrennen, "Gorbachev, Economics and the Environment," *Gorbachev's Economic Plans, Report for the Joint Economic Committee of Congress, Vol. II*, U.S. Government Printing Office, Washington, D.C., 1987, p. 398.

The demand for waste water treatment capacity is increased by water leakage into the the sewage collection system, resulting from faulty pipelines in the water supply distribution system. Such losses are estimated at 13 percent of annual water supply. Official statistics indicate that in 1986 such losses amounted to 40 cubic kilometers.<sup>2</sup> A study of 52 cities and towns in the Russian Republic reported that repairs to the water supply system could reduce fresh water consumption by up to 35 percent. Losses are also very high in Siberian cities, averaging 16.2 percent (2.2 times the statistical average for RSFSR).<sup>3</sup> Investments to curb these losses, however, seem unlikely and so demand for drinking water will put additional pressure on the water supply problem.

Fresh water supplies (estimated to be as high as 350 cubic kilometers annually) are supplemented each year with recycled water. Of the reported 250.9 cubic kilometers of water recycled in 1986, the largest portion is within industry. In 1982 the amount of industrial water demand met through recycling was as follows: petrochemical, 87 percent; pulp and paper, 53 percent; ferrous metallurgy, 80 percent; and non-ferrous metallurgy, 46 percent. More recent statistics for oil refining and petrochemicals indicate about 95 percent of water supplies are guaranteed by recycling.<sup>4</sup> Between 1982 and 1985, the capacity of industrial water recycling systems increased 15.3 percent or 32.5 cubic kilometers per year. The percentage of industrial demand fulfilled by recycled water, however, has remained constant at around 70 percent.<sup>5</sup>

### Demand and Cost

Estimates for the demand and cost of treating water vary considerably depending upon location, official acknowledgement of pollution problems, and level of cleanliness required. In assessing these variables it is important to keep certain principles in mind.

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<sup>2</sup>"Soviet Environmental Policies & Practices, Most Critical Investments," Section IV, University of Glasgow, 1988, p. 6.

<sup>3</sup>Glasgow report, p. 6.

<sup>4</sup>Glasgow report, p. 3.

<sup>5</sup>Zumbrunnen, pp. 405-406.

Table 14

VOLUME OF CIRCULATING AND REUSED WATER BY UNION REPUBLIC

Region	Total in Cubic Km			Percentage of Total Demand		
	1985	1986	1987	1985	1986	1987
USSR	244.4	250.9	264.2	69	70	71
Moldavian SSR						
Armenian SSR	2.3	1.8	2.5	82	78	83
Belorussian SSR	7.0	8.0	8.8	81	83	84
Ukrainian SSR	59.5	59.5	63.8	78	78	80
RSFSR	145.7	153.7	159.8	70	72	73
Kazakh SSR	11.5	12.1	12.2	60	61	62
Lithuanian SSR	2.9	2.9	3.0	57	52	52
Latvian SSR	0.5	0.5	.5	56	56	58
Tadzhik SSR	0.6	0.8	.7	53	57	53
Uzbek SSR	6.5	7.3	6.5	49	53	49
Kirgiz SSR	0.4	0.6	1.0	39	47	58
Azerbaydzhan SSR	1.8	1.8	1.9	38	39	40
Georgian SSR	1.0	1.0	1.0	37	37	42
Estonian SSR	0.9	0.9	1.0	26	25	26
Turkmen SSR	0.6	0.6	.7	21	23	25

First, dry climates and areas with low precipitation have a higher demand for recycled water. In certain areas such as the Ukraine and Central Asia, limited water resources lead to heavy dependence on recycling technologies to provide clean water. Second, the cost of cleaning water increases exponentially according to the degree of desired cleanliness. At 99 percent purity the cost is 10 times that at 90 percent, and at 99.9 percent it is 100 times more.<sup>6</sup> The third problem is that there is little agreement about the amount of water that needs to be cleaned. Although official Soviet data admit that 15.1 cubic kilometers of untreated effluents enter reservoirs, there are no official data available concerning the total quantity of "insufficiently cleansed" water released.<sup>7</sup> Finally, no official statistical information has been found on total waste water treatment

<sup>6</sup>Glasgow report, p. 9.

<sup>7</sup>Glasgow report, p. 10.

capacity. No statistics differentiate between municipal and industrial sectors or primary or reserve capacity, and no data represent the nature of technologies or geographic distribution.

In trying to make some sense of the official estimates of untreated waste water, Western experts have had to make some assumptions. The estimates assume that little if any of the water used in agriculture is treated and a very high percentage (about 85 percent) of industrial water is released untreated. This is largely because a great percentage of industrial water is used for cooling and is "normatively clean." Assuming that waste water treatment capacity is equal to the volume of normatively cleaned effluents that are released each year (22.9 cubic kilometers in 1986), treatment capacity is required for approximately 40 percent of total industrial and municipal effluents that are presently untreated.<sup>8</sup> In the RSFSR, a total of approximately 20 cubic kilometers of municipal and industrial effluents require treatment annually. The estimates indicate that the shortfall in treatment capacity for the RSFSR is about 6 cubic kilometers and 9.1 cubic kilometers for the rest of the USSR. But because reports on waste water treatment and sewage connections vary throughout the USSR a more general estimate of needed treatment capacity is between 3 and 6 cubic kilometers of municipal waste water and 12.1-9.1 cubic kilometers of industrial effluents.<sup>9</sup>

The following cost estimates were derived from budget allowances reported in Soviet journals and are not based on official data. These figures estimate the cost of installing 5 cubic kilometers of municipal waste water treatment capacity.

RSFSR	2.9 billion rubles (from 11th Five-Year Plan)
Latvia	2.3 billion rubles
Rostov Oblast	2.0 billion rubles
Tadzhikistan	1.2 billion rubles
Urals	854 million rubles

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<sup>8</sup>Glasgow report, p. 12.

<sup>9</sup>Glasgow report, p. 13.



Taking the middle range of costs of 2 billion rubles spent over 15 years would entail an expenditure of 133 million rubles annually or 665 million for each of three five-year plan periods.<sup>10</sup>

### Irrigation and Agricultural Water Use

About 50 percent of the fresh water supply in the Soviet Union is used for irrigation and agriculture. The amount of irrigation water used has declined recently, dropping from 161 cubic kilometers in 1980 to 146 cubic kilometers in 1986. This decline seems to reflect the growing awareness that excessive amounts of water have been used in irrigation and that this practice brings little or no return in increased agricultural production.

In an interview in *Kommunist* in March 1988, academicians B. N. Laskorin and V. A. Tikhonov both criticized Soviet agricultural practices for their wasteful use of water. Tikhonov noted:

Today, . . . . an excessively large amount of water is being wasted on irrigation, which salinizes and puts land out of circulation. Our irrigation rates are excessive and could be reduced by 15 percent without any harm (or, more accurately to the benefit of the crops). This alone, incidentally, would save about 20 cubic kilometers of water. . . . The condition in which irrigation systems are kept is beneath all criticism. According to the USSR People's Control Committee, in 1982 nearly one-half of the water collected for irrigation in Astrakhan, Volgograd and Rostov Oblasts and Krasnodar Kray was used un-productively. Losses have reached 40 percent in the Chernozem zone and as much as 60 percent in Central Asia, Kazakhstan and the Transcaucasus.<sup>11</sup>

Tikhonov estimated that the use of water for irrigation could be reduced by 60 cubic kilometers annually.

Tikhonov also commented on the returns on investment in water reclamation. Between 1971 and 1985 a total of 79.1 billion rubles were

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<sup>10</sup>Glasgow report, p. 15.

<sup>11</sup>B. N. Laskorin and V. A. Tikhonov, "New Approaches to Solving the Country's Water Problems," *Kommunist*, March 1988, in JPRS-UKO-88-009, May 9, 1988, p. 58

invested in water resource construction. Tikhonov noted that as a result of this investment a total of 11.7 million hectares of land were irrigated and 11.5 million hectares were drained.<sup>12</sup> The problems associated with improper irrigation techniques, including salinization, flooding, and erosion, however, had reduced the amount of usable land. The actual increase was 8.8 million hectares of irrigated land and 7.2 million hectares of drained land.<sup>13</sup> The investments per hectare of land for water reclamation increased substantially during this period. Between 1971-1975 investments were 3,700 rubles per hectare. From 1981-1985 this figure had jumped to 6,556 rubles per hectare.<sup>14</sup>

In addition to cost problems, Minvodkhov, the ministry responsible for water reclamation, also faces substantial delays in construction projects. In 1987 the full cost of the ministry's industrial construction projects totaled 29.6 billion rubles. The average lag between planned and actual rates of construction was 50 months. Tikhonov cited some of the most egregious situations:

The Pallaskovka irrigation system, estimated at 94.7 million rubles, has been under construction in Volgograd Oblast since 1967. It is 187 months behind the completion deadline. The Big Volgograd irrigation system has been under construction since 1973 (it is 108 months behind schedule). Nonetheless, without completing these and other construction projects, in 1986 the simultaneous construction of the Olenevskaya, Kalachevskaya, Kotelnikovo and Kamyshin irrigation systems was undertaken in the same oblast.

According to Tikhonov, Minvodkhoz has terminated or halted the construction of 2,213 projects totaling 1,225 billion rubles. "Of these 454 million rubles have already been totally lost."<sup>15</sup>

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<sup>12</sup>Laskorin and Tikhonov, p. 60.

<sup>13</sup>Laskorin and Tikhonov, p. 60.

<sup>14</sup>Laskorin and Tikhonov, p. 60.

<sup>15</sup>Laskorin and Tikhonov, p. 60.

## AIR POLLUTION

Since 1985, ambient air quality in nearly 500 Soviet cities has been monitored, and in about 70 percent of these cities dust, sulfur dioxide, and hydrogen emissions are reported as stabilized or reduced. All newly constructed industrial facilities are required to install gas scrubbers and dust traps. Soviet air pollution abatement programs, however, are still inadequate. In 1982, air pollution control equipment was found to be inoperable or ineffective at the following rates.<sup>16</sup>

Ministry	Percentage of Equipment Not Working
Petroleum & petrochemical	17
Ferrous metallurgy	25
Mineral fertilizer	25
Non-ferrous metallurgy	27
Power and electrification	40

Table 15 summarizes the quantities of harmful substances intercepted from industrial gaseous emissions. The fraction of the substances trapped has been an almost constant 76 percent from 1982-1987.

Table 15

INTERCEPTION AND NEUTRALIZATION OF HARMFUL SUBSTANCES BEING  
DISCHARGED FROM STATIONARY SOURCES OF AIR POLLUTION, USSR  
(In millions of metric tons)

Quantity Intercepted			Percentage of Total Emissions		
1985	1986	1987	1985	1986	1987
205.3	207.2	212.3	76	76	77

<sup>16</sup>Zumbrunnen, p. 408.

According to official Soviet statistics, the volume of harmful substances intercepted in 1985 increased more than 15 million metric tons (8 percent) over 1980 levels. Supposedly, the quantity of harmful substances entering the atmosphere has decreased by 5 percent over the 1981-1985 period.<sup>17</sup> These statistics, however, seem to Craig Zumbrennen to be inflated; he suggests that the Soviets have not actually been this successful.

Recent accounts in the Soviet press indicate that Zumbrennen is probably right. According to an article by I. Mosin in *Socialist Industry*, September 23, 1988:

The emission of harmful substances into the atmosphere is being reduced only extremely slowly. Discharges into the air in nine cities led to the maximum permissible concentration being exceeded 50-fold. An extremely serious situation has taken shape in the region of the Astrakhan gas condensate complex. In a 12-km zone in which some 30,000 people live, the level of harmful substances in the atmosphere is more than 5 times above the permissible threshold.<sup>18</sup>

The air quality problem is made worse by emissions from motor vehicles. On July 25, 1988, the Commission for the Conservation of the Environment met to discuss the impact of environmental legislation. The commission noted that motor transport accounts for 40 percent of the total quantity of pollutants discharged into the air. Efforts to produce effective systems for neutralizing motor vehicle exhaust, however, have been unsuccessful and the Soviets must purchase this technology from abroad. An additional problem is that the fuels needed to operate motor vehicles with pollution control systems are in short supply, and the Ministry of the Petroleum Refining and Petrochemical Industry has been unable to increase production. There is also insufficient production of antismoke additives for diesel fuel. Although directives have been issued to reduce the problems of motor

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<sup>17</sup>Zumbrennen, p. 409.

<sup>18</sup>I. Mosin, "Notes from USSR Supreme Soviet Commission Session: Nature Cannot Wait," *Sotsialisticheskaya Industriya*, September 23, 1988, in FBIS-SOV-88-187, September 27, 1988, p. 1.

vehicle exhaust, "the ministries and departments that operate transport facilities and the union republic councils of ministers are not taking proper steps to switch motor transport to operating on compressed natural and liquified petroleum gases, to improve motor traffic movement, and to create monitoring and tuning posts at automotive enterprises and technical servicing stations."<sup>19</sup>

## OVERVIEW OF SOVIET ENVIRONMENTAL POLICY

Assessing environmental policy for the Soviet Union is somewhat tricky, given that there are few if any concrete standards by which to measure success. If Western estimates are close to accurate, the Soviets still suffer from shortages of both water and air pollution control equipment. The Soviets themselves have been very open about the current environmental problems and insistent that something should be done. The evidence from the Soviet Union, however, does not seem to confirm a real commitment to environmental protection. Although the Soviets have evidently increased their spending on environmental protection, the actual installation of equipment and regulation of emissions seems inadequate to accomplish their stated environmental goals. Tables 16 and 17 summarize the capacity of newly installed equipment to prevent water and air pollution.

Between 1981 and 1987, the Soviets spent a total of 64 billion rubles on the protection and rational use of resources.<sup>20</sup> In both 1986 and 1987 total expenditures were around 10 billion rubles.<sup>21</sup> In 1987, this figure included 5.3 billion rubles in maintenance and operation of resource conservation installations and structures, over one billion rubles in expenditures on forestry resources, and 2.7 billion rubles in state capital investment. The projected expenditures for the 12th Five-Year Plan are 15 billion rubles in state capital investment.<sup>22</sup>

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<sup>19</sup>A. Vorobyev, "Nature Demands a Prosecutor," *Sotsialisticheskaya Industriya*, August 6, 1988, p. 4, in FBIS-SOV-88-160, August 18, 1988, p. 34.

<sup>20</sup>*Narodnoye Khozyaustvoe*, 1987, p. 577.

<sup>21</sup>*Narodnoye Khozyaustvoe za 70 let*, p. 718.

<sup>22</sup>*Narodnoye Khozyaustvoe*, 1987, p. 577.

Table 16

NEWLY INSTALLED CAPACITY FOR PREVENTING  
WATER AND AIR POLLUTION

	1976-80	1981-85	1985	1986	1987
Purifying water waste in millions of cubic meters/day	36.9	26.8	4.0	7.0	5.1
Water recycling in millions of cubic meters/day	121.7	122.1	29.1	24.6	29.9
Air pollution controls in millions of cubic meters/hours of gas	172.4	200.0	36.5	38.8	48.2

Table 17

STATE CAPITAL INVESTMENT IN MEASURES FOR NATURE PROTECTION  
AND RATIONAL USE OF NATURAL RESOURCES  
(In millions of rubles)

	1971-75	1976-80	1981-85	1985	1986	1987
Water	5,411	8,338	8,087	1,683	1,798	1,902
Air	725	950	899	234	263	273
Total	7,291	10,824	1,120	2,486	2,615	2,663

Absorption of allocations for environmental protection, however, seems to be a major problem. According to a report by A. Vorobyev in Socialist Industry, August 6, 1988:

Persuasion and formal fines cannot shake the legal nihilism of economic planners who ignore government resolutions and laws on environmental conservation, and references to a lack of funds do not stand up to criticism. An average of R30 billion is being allocated during the 5-year plan. But ministries are not assimilating these funds, particularly with regard to water conservation measures. Not one government resolution on basins and rivers has been filled.<sup>23</sup>

<sup>23</sup>Vorobyev, p. 34.

USSR Gosplan reports that:

The construction of USSR Council of Ministers environmental protection projects, has fallen seriously behind schedule: The Kazakh SSR assimilated 26 percent of the year's capital investment quota in the first 6 months of 1988, the Moldavian SSR assimilated 32 percent, and the Azerbaijan SSR assimilated 27 percent. The RSFSR Council of Ministers fulfilled only 26 percent of the plan for the first half of this year for the commission of water purification units.<sup>24</sup>

The document goes on to say that in 1989 the environmental situation will deteriorate even further.

The USSR Ministry of the Timber Industry and USSR Ministry of the Petroleum Refining and Petrochemical Industry have made virtually no provision for commissioning purification units. As a result, instead of reducing the discharge of polluted effluent, in 1989 enterprises belonging to these ministries will, in fact increase the volume by 517 million and 155 million cubic metres respectively.<sup>25</sup>

## PROSPECTS FOR FUTURE INVESTMENT IN ENVIRONMENTAL PROTECTION

Estimating expenditures on environmental protection is especially difficult because of uncertainty about the current level of technology employed in environmental cleanup. It is generally believed that the Soviet Union lags behind the West in both technology and enforcement of environmental regulations. Because of these differences, comparisons of rates of spending in various countries are particularly problematic. The following comparison with U.S. expenditure on environmental protection should be viewed in the context of differing levels of industrialization and economic developments, technology and public concern, and pressure regarding environmental protection.

During the 1980s, investment in pollution control in the United States fell from the levels of the 1960s and 1970s. Using statistics

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<sup>24</sup>Mosin, p. 59.

<sup>25</sup>Mosin, p. 56.

from 1985, pollution control expenditures were targeted at 2.7 percent of capital spending, a substantial decline from the 5.7 percent spent in 1976.<sup>26</sup> But although investment in pollution control declined as a percentage of capital spending, expenditures in the mid-1980s were still substantial. In 1984 and 1985, investment for pollution control was over \$10 billion.<sup>27</sup> Although it is true that investment in the United States is largely private, whereas in the Soviet Union all investment allocations are centrally determined, the U.S. rates provide one standard against which to measure and project Soviet investment in environmental protection.

Soviet investment in environmental protection has never absorbed as high a percentage of capital investment as in the United States. In 1985, capital investment for the protection and rational use of natural resources was roughly 2.5 billion rubles.<sup>28</sup> This was about 1.4 percent of the total capital investment of 179.5 billion rubles in 1985.<sup>29</sup> During both the 9th and 10th Five-Year Plan periods the share was about 1.1 percent. For 1987, the percentage was about 1.3. Compared to the United States, their rate of investment in environmental protection has remained quite stable as a proportion of overall capital investment.

According to the official statistical handbook from 1986, projected growth in capital investment through the 12th Five-Year Plan is 23.6 percent above the 11th Five-Year Plan. Capital investment in the 11th FYP was 843.2 billion rubles.<sup>30</sup> Using the projection of a 23.6 percent increase, capital investment during the 12th Five-Year Plan should be about 1037.14 billion rubles. This would represent an annual increase in capital investment of between 4 percent and 4.5 percent. The planned capital investment in environmental protection for this period is stated in the handbook to be 15 billion rubles. This constitutes about 1.4 percent of total capital investment for the 12th FYP.

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<sup>26</sup>"Eighteenth Annual McGraw-Hill Survey of Pollution Control Expenditures, 1984-1986," McGraw Hill Economics, New York, 1985, p. 1.

<sup>27</sup>McGraw Hill survey, p. 1.

<sup>28</sup>Narkhoz za 70 let, p. 618.

<sup>29</sup>Narkhoz za 70 let, p. 329.

<sup>30</sup>Narkhoz za 70 let, p. 329.



The Soviet authorities have acknowledged that these rates of investment are too low to adequately deal with the environmental problems currently facing the Soviet Union. In a speech to the Congress of People's Deputies in June 1989, Nikolai Ryzhkov, Chairman of the Council of Ministers announced that the Soviet leadership intended to allocate R135 billion during the course of the next three five-year plans for pollution control. This would mean an average of R45 billion in each five-year plan period in contrast with the 15 billion of the current plan.<sup>31</sup>

In the following projections, the level of expenditure proposed by Ryzhkov is used in the high estimates of state capital investment. The low and medium estimates are more in keeping with traditional Soviet expenditure on environmental protection.<sup>32</sup>

The high estimate for 1995 assumes growth in total capital investment at 4.5 percent per year yielding a figure of around 280 billion rubles. State capital investment is estimated at 9 billion rubles which is the average annual expenditure proposed by Ryzhkov. This constitutes about 3.2 percent of projected total capital investment, a high percentage given the Soviets past performance but within the range of that expended in the United States. The maintenance

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<sup>31</sup>Ryzhkov Addresses Congress, FBIS-SOV-89-109, June 8, p. 27.

<sup>32</sup>The formal model for the projections is as follows: For state capital investment

$$a[T(1 + r)^n]$$

where  $a$  = percentage of total capital investment spent on environment,  
 $T$  = total capital investment in base year,  
 $r$  = rate of growth of total capital investment,  
 $n$  = number of years following the base year.

For operating and maintenance figures a simple growth model is used

$$M(1 + r)^n$$

where  $M$  = total maintenance costs in base year,  
 $r$  = rate of growth of maintenance costs,  
 $n$  = number of years following the base year.

The calculations use the statistics from 1987 as the base.

and operating funds designated for environmental protection are targeted to grow by 4.5 percent per year, yielding a figure of 10 billion rubles.

The medium estimate keeps overall capital investment at the same level but reduces the percentage used for environmental protection to 2 percent. This produces a figure of 5.6 billion rubles. Although the percentage of investment is high by Soviet standards, the new emphasis on environmental concerns makes this a possible alternative to Ryzhkov's proposal. The growth in the operating and maintenance funds is reduced to 4 percent yielding 9.5 billion rubles.

The low estimate combines a slower rate of overall growth with investment for environmental protection returning to the lower rates of the 11th FYP. The low estimate is based on a growth rate of 3 percent per year for overall capital investment bringing the total to around 253 billion rubles. With a 1.1 percent rate of investment in environmental protection the figure is 3 billion rubles. Other funds are increased at a rate of 3.5 percent per year with the total expenditure of 9 billion rubles (see Table 18).

The estimates for the year 2000 follow the same pattern as those for 1995. The high estimate for state capital investment is kept at 9 billion rubles. The other estimates are based on a total capital investment figure of 357.36 billion rubles with the percentages going toward environmental protection the same as in the 1995 projection (see Table 19).

Table 18

PROJECTED EXPENDITURES FOR ENVIRONMENTAL PROTECTION: 1995  
(In billions of rubles)

	High	Medium	Low
State capital investment	9	5.6	3
Operations, maintenance, and other expenditures	10	9.5	9
Total	19	15.1	12

Table 19

PROJECTED EXPENDITURES FOR ENVIRONMENTAL PROTECTION: 2000  
(In billions of rubles)

	High	Medium	Low
State capital investment	9	7	4
Operations, maintenance, and other expenditures	13	12	11
Total	22	19	15

For the overall capital investment statistics for 2010, it is assumed capital investment will increase at 5 percent per year to the year 2000 and then decrease to 3 percent per year over the next ten years. The basis for this estimate is the official handbook prediction of a 5 percent increase in national income during the 14th Five Year Plan.<sup>13</sup> Given the current economic situation in the Soviet Union, this prediction seems highly optimistic. Assuming that such high levels could be achieved in the 1995-2000 period, growth would probably slow in the following decade returning to more typical levels of growth.

The high estimate for expenditure on environmental protection uses 480 billion rubles as the total amount of capital investment in the year 2010. By this year, Ryzhkov's proposed investments would have already been made but high levels of capital investment for pollution control could have become standard parts of budgeting. Using a figure of 3 percent of total capital investment for environmental protection, the figure for the year 2010 would be 14.4 billion rubles. With maintenance and operating costs increasing at 4.5 percent per year, these costs would total 19 billion in 2010.

The medium estimate is derived from investment in environmental protection constituting 2 percent of total capital investment, yielding 9.6 billion rubles. Other costs are slated to increase at 4 percent per year, totaling 17 billion.

<sup>13</sup>Narkhoz za 70 let, p. 52.

For the low estimate, 1 percent of capital investment is absorbed in environmental protection. Other costs increase at a rate of 3 percent per year yielding 14 billion rubles in additional expenditure (see Table 20).

Table 21 shows the projected expenditure statistics deflated to 1982 rubles. The deflators assume a 5 percent inflation rate.

Table 20

PROJECTED EXPENDITURES FOR ENVIRONMENTAL PROTECTION: 2010  
(In billions of rubles)

	High	Medium	Low
State capital investment	14.4	9.6	4.8
Maintenance, operations, and Other Expenditures	19	17	14
Total	33.4	26.6	18.8

Table 21

TOTAL EXPENDITURES FOR ENVIRONMENTAL PROTECTION  
(In billions of 1982 rubles)

	1995(a)			2000(b)			2010(c)		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
State capital investment	4	3	2	4	3	2	4	3	1
Maintenance, operations, and other expenditures	5	5	5	5	5	5	5	4	4
Total	9	8	7	9	8	7	9	7	5

NOTES: Estimates are rounded to the nearest billion.

(a) Deflator 1995 = 1.9.

(b) Deflator 2000 = 2.4.

(c) Deflator 2010 = 3.9.

Appendix

TABLES ON EXPENDITURES FOR TRANSPORTATION, ENERGY,  
AND ENVIRONMENTAL PROTECTION

The following tables show the projected expenditure statistics in both current and 1982 rubles. The deflators assume a 5 percent inflation rate.

Table A.1

EXPENDITURE STATISTICS FOR ENVIRONMENT AND TRANSPORTATION: 1987  
(In billions of rubles)

	1987	1987(a)
Environment		
State capital investment	2.7	2.1
Operations & maintenance	7.3	5.6
Total	10	7.7
Transportation and Communications		
Capital investment	24	18.5
Working capital	17.2	13.2
Capital repair	8.4	6.5
Total	49.6 - 50	38.2

(a) In 1982 rubles. The figure assumes an inflation rate of 5 percent per year. The deflator is 1.3.

Table A.2

PROJECTED EXPENDITURES FOR ENVIRONMENTAL PROTECTION: 1995  
(In billions of rubles)

	High	Medium	Low
State capital investment	8	5.6	3
Operations, maintenance, and other expenditures	10	9.5	9
Total	18	15.1	12

Table A.3

PROJECTED EXPENDITURES FOR ENVIRONMENTAL PROTECTION: 2000  
(In billions of rubles)

	High	Medium	Low
State capital investment	10	7	4
Operations, maintenance, and other expenditures	13	12	11
Total	23	19	15

Table A.4

PROJECTED EXPENDITURES FOR ENVIRONMENTAL PROTECTION: 2010  
(In billions of rubles)

	High	Medium	Low
State capital investment	14.4	9.6	4.8
Maintenance, operations, and other expenditures	19	17	14
Total	33.4	26.6	18.8

Table A.5

TOTAL EXPENDITURES FOR ENVIRONMENTAL PROTECTION  
(In billions of 1982 rubles)

	1995(a)			2000(b)			2010(c)		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
State capital investment	4	3	2	4	3	2	4	3	1
Maintenance, operations, and other expenditures	5	5	5	5	5	5	5	4	4
Total	9	8	7	9	8	7	9	7	5

NOTE: Estimates are rounded to the nearest billion.

(a) Deflator 1995 = 1.9.

(b) Deflator 2000 = 2.4.

(c) Deflator 2010 = 3.9.

Table A.6

TOTAL EXPENDITURES FOR TRANSPORTATION AND COMMUNICATION  
(In billions of rubles)

	1981-85	1986-90	1991-95		
			High	Medium	Low
Capital investment	104.3	105.2	125	119	105
Operating capital	71.4	90.97	116	116	116
Capital repair	24.72	46.6	65	61	61
Total	210.42	242.77	306	296	282

NOTE: Estimates are rounded to the nearest billion.

Table A.7

TOTAL EXPENDITURE<sup>c</sup> FOR TRANSPORTATION: 1995, 2000, AND 2010

	1995			2000			2010		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
Fixed capital investment	28	25	22	34	30	26	45	42	32
Operating capital	25	25	25	32	32	31	52	52	50
Capital repair	15	14	14	22	19	18	36	33	30
Total	68	64	61	88	81	75	133	127	112

Table A.8

TOTAL EXPENDITURES FOR TRANSPORTATION AND COMMUNICATION  
(In billions of 1982 rubles)

	1995(a)			2000(b)			2010(c)		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
Fixed capital investment	15	13	12	14	13	11	12	11	8
Operating capital	13	13	13	13	13	13	13	13	13
Capital repair	8	8	7	9	8	8	9	8	8
Total	36	34	32	36	34	32	34	32	29

(a) Deflator for 1995 = 1.9.

(b) Deflator for 2000 = 2.4.

(c) Deflator for 2010 = 3.9.



Table A.9

ENERGY SECTOR RESOURCE USE  
(In billions of 1982 rubles)

Year	High	Medium	Low
1990	35.7	28.2	24.3
1995	60.3	37.6	27.7
2000	97.8	49.2	31.4